Carol A. Raymond

Suzanne E. Smrekar & Ellen R. Stofan

Jet Propulsion Laboratory
California Institute of Technology
Pasadena, CA

- **Preliminary analysis based on available data!**
  - Spatial distribution of magnetism from published maps
  - Relationship to regional gravity, topography and crustal thickness
- **Addresses questions:**
- **Preliminary conclusion and implications**

- Intense magnetic anomalies occur in the Southern highlands
- Magnetized crust generally limited by the dichotomy boundary, but anomalies clearly extend across the boundary
- Weaker anomalies in Northern lowlands and north polar region
- Crust at large impact basins and large volcanic structures is apparently non-magnetic
  - Tharsis, Utopia, Isidis, Hellas, Argyre, Elysium
- Arabia Terra crust is strongly magnetic but has affinity to lowlands crust (e.g Zuber et al., 2000)
- No dominant polarity is apparent
- Fine structure is present in anomaly pattern
- No strong correlation between magnetic and gravity anomalies

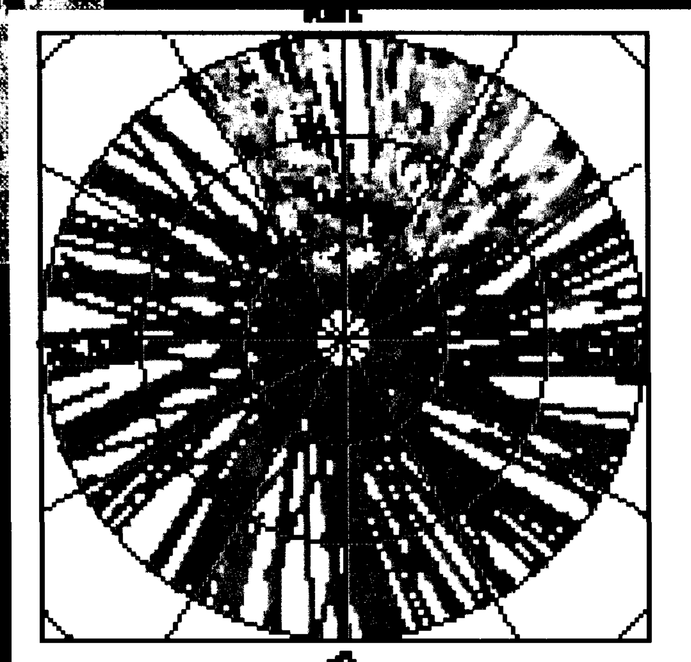
[illegible] Con[illegible]ion

The spatial distribution of the magnetic anomalies, and their relationship to the gravity and topography, the dichotomy and resurfacing history, suggests that strongly magnetic crust retains an original magnetization acquired at formation while weakly to non-magnetic crust has experienced subsequent tectonic modification by resurfacing, heating and intrusions such that its original magnetization has been destroyed

- Crust formed in presence of strong internal dipole field imprinting thermoremanence
  - Global distribution of anomalies implies global process
  - Apparent early Noachian age of magnetized regions coincident with major crustal growth phase
  - Arabia Terra may be an exposed surface of northern lowlands basement based on its crustal thickness (Zuber et al., 2000) and is strongly magnetized
- Crust experienced hydrothermal alteration in presence of strong internal dipole field resulting in chemical remanence (e.g. Baker and Sprenke, 1999)
  - Would require vigorous global hydrothermal circulation

- Accretion at quasi-linear plate boundary - problematic:
  - No axis of symmetry is present
  - No evidence of plate boundaries preserved in gravity field
  - Anomaly pattern is chaotically lineated
  - Time required to cool thick crust is substantial - difficult to maintain vertical magnetic contrasts (increases mag intensity required) if field was reversing every few million years
- Rifting of coherently magnetized lithosphere
  - Requires large amounts of extension
  - Requires high magnetization intensity for single polarity case
- Thrust-style stacking of thin, highly magnetized bouyant crustal slabs at proto-subduction zones

For spreading origin, requires systematic offsets

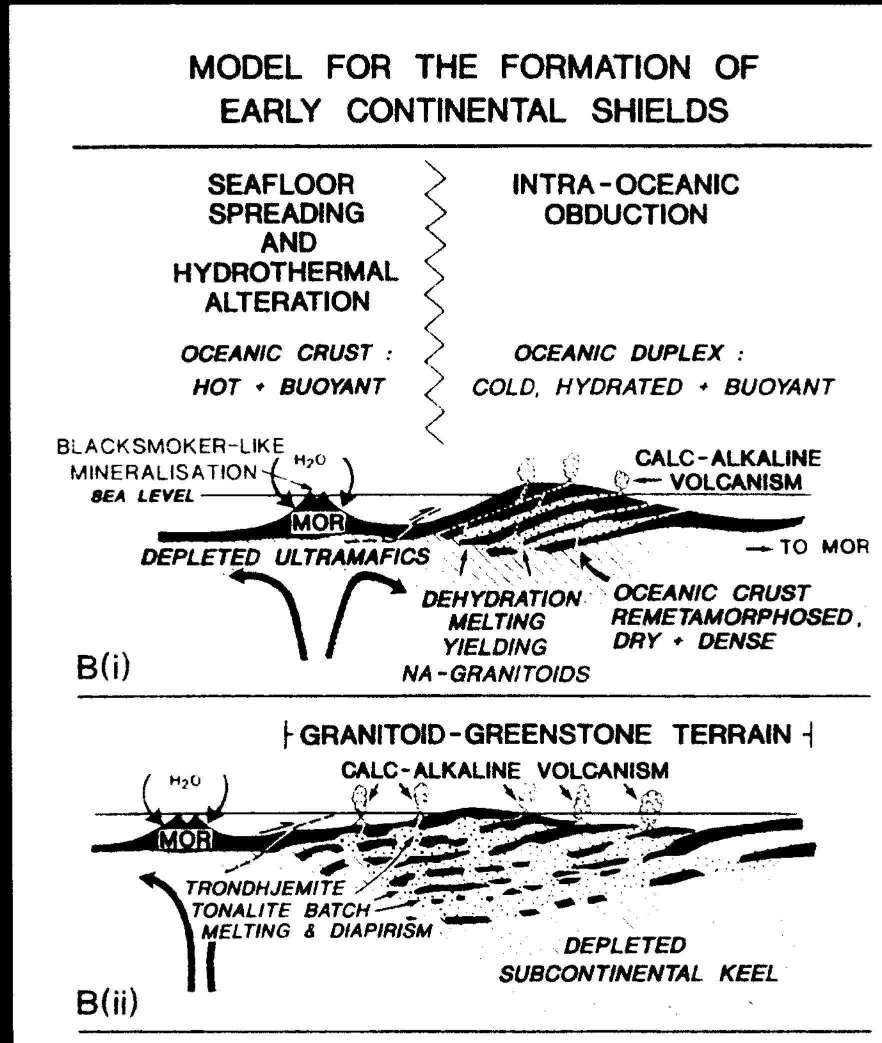


Geometry favored by subduction zones/magmatic arcs

- Minimum width of individual rifts is ~50 km to reproduce the minimum wavelength in the observed anomalies
- Lack of polarity bias in observed anomaly field indicates very significant extension required to produce alternating polarity pattern
- Magnetization contrast required is of order 30 A/m for 30 km thick crust
  - 15 A/m magnetization intensity for dual-polarity model
  - 30 A/m intensity for single polarity model
- Gravity data do not support a rifting structure of the scale required by the magnetic observations

A possible analog of early crustal accretion on Mars and subsequent deformation at proto-subduction zones

- Hydrous crust would result in enhanced magnetization
- Thin (ca. 10 km) slabs would cool quickly to block in thermoremanence
- Stacking of slabs would result in thick crust
- Subsequent volcanism is possible mechanism for intracrustal magnetic contrasts
- Subcontinental keel resists subduction or modification and results in low heat flow



M. J. deWit, 1998. Geologie en Mijnbouw, **76**, 369.

- Crust formed after internal field decayed
  - Implies subduction of original lithosphere
- Crust was modified after internal field decayed
  - Reheating of crust above Curie temperature of magnetic mineral assemblage:
    - Burial by thick sediments and/or enhanced heat flow
    - Volcanic resurfacing and/or crustal intrusions
    - Vigorous hydrothermal circulation
  - Destruction of crust:
    - Delamination
    - Thinning by large impacts

- Crustal thinning and shock heating would destroy or reduce original crustal magnetism - but only in the crater
- Ejecta blanket too small to bury or disrupt the source layer
- Area of non-magnetic crust surrounding the Hellas and Argyre basins is too large to implicate the impacts as a demagnetizing force
- Thermal rejuvenation and/or crustal underplating, possibly driven in part by lateral temperature gradients induced by crustal thickness variations, may have destroyed the original magnetism

⇨ ***The age of the Hellas and Argyre impacts is not a limit on the longevity of the internal dipole field***

- Isolated and weak anomalies in northern hemisphere are fragments of ancient 'primordial' crust and argue against a distinct plate tectonic regime for the northern lowlands
- Reheating of ancient crust above Curie temperature (burial or volcanism), or its removal, created non-magnetic regions
- Impact-related demagnetization is only locally significant, requiring widespread reheating of crust in the Hellas/Argyre region (underplating?)
- Hellas/Argyre impacts do not constrain field history
- Early Archean terrestrial analog may be useful to understand anomaly pattern and very strong crustal magnetization